

No. 9.— *New Blastoids and Brachiopods from the Rocky Mountains.*

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BLASTOIDEA.

BLASTOIDS are so rare in the Rocky Mountains that the discovery of new species of these fossils in that region is of considerable interest and importance. In 1915, while a member of the Harvard Summer School of Geology, I was fortunate enough to find several specimens belonging to *Pentremites* and *Schizoblastus* in the Carboniferous limestone of southwestern Montana. The discovery of these fossils here is important from another point of view, namely, that the *Pentremites* were collected from that part of the Carboniferous limestone which must be acknowledged to be of Pennsylvanian age. The specimens of *Schizoblastus* and one *Pentremites* came from Squaw Creek, off the West Gallatin River, and the other *Pentremites* were collected at Old Baldy, near Virginia City, Montana.

At Old Baldy, there is an exposure of Carboniferous limestone, the greater part of which contains fossils characteristic of the Madison formation (Mississippian). The limestone is capped by the Quadrant quartzite, which is recognized as Upper Carboniferous. Immediately below the quartzite there is a considerable thickness of limestone which contains Pennsylvanian fossils. Schuchert, in 1910, writing of the Old Baldy fossils stated that "in the light of the Arkansas (Morrow formation) collections, these fossils must now be referred to the Pottsvillian" (Bull. Geol. soc. Amer., 20, p. 426-606).

Since 1873, when Meek published his lists of fossils collected from the rocks of Montana (Meek, Rept. U. S. geol. surv. Montana Idaho, Wyoming, Utah, 1873, p. 463-478), nothing has been published concerning *Pentremites* in the Rocky Mountains, and Meek was the first to discover this genus west of Iowa and Missouri. In the report referred to above the occurrence of the following five species is noted:—*Pentremites conoideus*, *Pentremites subconoideus*, *Pentremites symmetricus*, *Pentremites godoni?*, *Pentremites bradleyi*. These come from two localities in Montana. In 1905, Mr. Earl Douglass found a specimen at Old Baldy, which was identified by Dr. P. E. Raymond as *Pentremites conoideus*, and the description of which appears in this paper for the first time. The discovery by the writer of three new species of *Pentremites* adds considerably to the

representation of the genus in the Rocky Mountain Region, and suggests the desirability of obtaining further information upon the occurrence of the genus in that region.

The genus *Schizoblastus* has had a similar history. In 1874 White described one species, *Schizoblastus lotoblastus*, from the Subcarboniferous of Arizona, and in 1879 noted the same species from the Carboniferous of the Teton range. Dr. W. P. Haynes brought back from the Carboniferous at Squaw Creek, Montana, three specimens of the genus, which, owing to their imperfect preservation, he could not distinguish from *Schizoblastus lotoblastus*. From the same locality the writer collected several silicified specimens which, etched, were plainly not conspecific with *Schizoblastus lotoblastus*.

A blastoid like *Pentremites subconoidcus* has been found at Frank, Alberta, in the Carboniferous limestone, and indicates the occurrence of blastoids in that part of the Rockies.

Dr. K. F. Mather, in 1915, published *The Fauna of the Morrow Formation of Arkansas* (Bull. Sci. lab. Denison univ., 1915, 28, p. 59.) in which he described two species of *Pentremites* from the Pennsylvanian. The possibility that the limestone at Old Baldy, or at least the upper part of it, is of Pennsylvanian age has frequently been considered. The Quadrant sandstone is certainly calcareous at its base, and also fossiliferous. The only fossils directly associated with the *Pentremites* found by the writer at Old Baldy are *Hustedia mormoni* and *Spiriferina kentuckiensis*, both of which indicate an Upper Carboniferous horizon. We must therefore cease to think of the genus *Pentremites* as becoming extinct with the close of the Mississippian, and recognize it as extending, at least in the Rocky Mountains and in Arkansas, over into Pennsylvanian time.

I would suggest the advisability of comparing species of blastoids not solely by means of written descriptions, but with the help of actual measurements. Such measurements are at the same time both a check upon the description, and in some ways a shorthand expression of it. Frequently, disconnected measurements have been given in descriptions of species but until Mather's paper no recognized set of measurements had been used. It will be seen, however, that mere listing of the actual measurements of blastoids will lead to endless confusion unless we have a datum point to start from. I suggest, in this connection, that actual measurements of *Pentremites* be adjusted to a standard height for each specimen of twenty millimeters. Obviously the measurements of adult forms only should be adjusted in this manner, and each investigator must use his own discretion in rejecting specimens too young to be treated. Individual variations

within a given species may tend to detract from the advantage of this system of tabulating the characteristics of *Pentremites*, but, on the whole, I feel confident that such a system will be of great help in separating the species of this genus.

For *Schizoblastus*, I have used a standard of ten millimeters, fearing lest further magnification should multiply unavoidable errors in measurements. For larger specimens than ours, twenty millimeters may prove to be better.

The following pages contain a list of all blastoids which have, to the knowledge of the writer, been reported from the Rocky Mountains.

PENTREMITES SAXIOMONTANUS, sp. nov.

Plate 1, fig. 1-6, 14.

Description.—Body of medium size, ovate, thickest at the base of the ambulacra. Basal portion obconical, prominent, occupying about a quarter of the length of the specimen. The radial plates are narrow, each with a markedly prominent angular median ridge below the bifurcation; that part of the radials between the ridges being perfectly flat. Each fork of the radials is slightly convex, thus making a median depression along each interambulacral area. The radials are ornamented with fine striae running parallel to the suture, ending against the ambulacral border, and apparently converging slightly towards the base. Deltoids very small, unornamented, short, and narrow. The interambulacral area shows only a slightly raised border, in some specimens none at all. The ambulacra extend to the thickest part of the body, about three quarters the entire length, enlarging constantly to near the summit; hence the sides are not subparallel.

*Dimensions of three specimens*¹ in millimeters.

Height.....	13.	14.	15.
Maximum diameter.....	9.	10.	12.
Length of ambulacral plates.....	9.	9.5	10.5
Maximum width of ambulacral area...	3.8	3.5	4.
Length of deltoid plates.....	2.5	3.5	3.
Maximum width of deltoid plates.....	1.5	1.5	1.5
Average number of side-plates in 5 mm..	13.	16.	13.

¹ These three specimens are figured on Plate 1, in order, fig. 4, 1, and 14.

Dimensions of the three specimens adjusted to a height of 20 millimeters.

Height.....	20.	20.	20.
Maximum diameter.....	13.8	14.3	16.
Length of ambulacral area.....	13.8	13.6	13.7
Maximum width of ambulacral plates..	5.8	5.	5.3
Length of deltoid plates.....	3.8	5.	4.
Maximum width of deltoid plates.....	2.3	2.1	2.

Formation and locality.— I collected this species from the limestone member of the Quadrant formation at Old Baldy, near Virginia City, Montana, and at Squaw Creek off the West Gallatin River.

Pentremites symmetricus (Kaskaskia limestone of Kentucky) most nearly resembles *Pentremites saxiomontanus*, but its interambulacral areas are concave; in *Pentremites saxiomontanus* they are flat. The base of the latter species is not so stout, and the summit has a smaller area. The lesser prominence of the median ridges on the radials in *Pentremites symmetricus*, too, is a marked difference. The angle made by the sutures between the deltoid and radial plates in *Pentremites symmetricus* is obtuse, in *Pentremites saxiomontanus* very acute.

Pentremites pyriformis (Mississippian of Alabama, Tennessee, Kentucky, Illinois, Indiana, Missouri) is thickest in the middle and rounded in outline, while *Pentremites saxiomontanus* is decidedly angular. The deltoids are smaller in *Pentremites pyriformis*, and the basal portion is more elongate.

One of the specimens, as etched from the matrix, showed a very slender column, which would help to distinguish it from *Pentremites gemmiformis* (Kaskaskia of Illinois). The latter species possesses a rim around the ambulacral area and sixteen side-plates in five millimeters.

In *Pentremites elegans* (Millstone grit of Kentucky, Maxville limestone of Ohio) the deltoids are small, occupying but one sixth the length of the body. The ambulacra are, relatively, considerably shorter than those of *Pentremites saxiomontanus*, and in outline too much rounded below. Moreover in *Pentremites elegans* there are twenty-one side-plates in five millimeters.

PENTREMITES DIVERGENS, sp. nov.

Plate 1, fig. 7-10.

Description.— Small, thickest at the base of the ambulacra. Width and height subequal, the body being slightly higher than wide. Basal portion obconical, occupying about one third the length of the specimen. The basal plates are obscured in the type. The radials are prominently angular below the ambulacra, forming a longitudinal ridge extending from the base of the ambulacra to the basals; the spaces between these ridges are concave. The interambulacral areas narrow rapidly upwards and are depressed along each median suture; there is no rim bordering the interambulacral areas. The deltoids are small, less than a quarter the length of the whole body, acuminate, the tip somewhat incurved towards the oral aperture. Oral opening and spiracles large, shape uncertain. The ambulacral areas enlarge rapidly upwards, the lower end distinctly rounded in outline, and not angular. There are from fifteen to sixteen side-plates in the space of five millimeters.

Dimensions of two specimens in millimeters.

Height.....	11.	—
Maximum diameter.....	10.	8.5
Length of ambulacral area.....	7.5	6.25
Maximum width of ambulacral plates.....	3.25	3.
Length of deltoid plates.....	2.5	1.5
Maximum width of deltoid plates.....	1.0	.5
Average number of side-plates in 5 mm.....	16.	15-16

Dimensions of the two specimens adjusted to a maximum diameter of 18 mm.

Height.....	20.	—
Maximum diameter.....	18.	18.
Length of ambulacral area.....	13.6	13.2
Maximum width of ambulacral plates.....	5.9	6.3
Length of deltoid plates.....	4.5	3.1
Maximum width of deltoid plates.....	1.8	1.1

Formation and locality.— The specimens were collected by the author from the limestone member of the Quadrant formation at Old Baldy.

This species can be distinguished from either *Pentremites altimarginatus* or *P. saxiomontanus* by its rotund form.

Pentremites cervinus (Mississippian of Alabama and Illinois) is more angular, especially below the ends of the ambulacra. In *Pentremites divergens* the deltoids are more than twice as long as wide, while in *Pentremites cervinus*, according to the figure they are only one half longer than wide, therefore less mucronate. The ambulacra expand very gradually toward their widest part.

Pentremites cherokeeus (Mississippian of Alabama, Illinois, and Tennessee) is a larger form whose deltoids project above the oral aperture. The angles at the bases of the ambulacra are too prominent to be *Pentremites divergens*, and the interambulacral areas are deeply concave. Moreover *Pentremites cherokeeus* is considerably thicker than high and the summit (including the deltoids) is two thirds as wide as the maximum thickness of the specimen.

Pentremites koninckanus (Mississippian of Indiana, Illinois, Iowa, Missouri) has much shorter ambulacra and deltoids.

Pentremites bradleyi (Carboniferous of Montana) has its ambulacra deeply excavated along the middle. In *Pentremites divergens* the ambulacra are scarcely grooved at all. The flat base of *Pentremites bradleyi* is the most distinguishing feature of the species. The latter species has nineteen side-plates in five millimeters, *Pentremites divergens* fifteen to sixteen.

Pentremites rusticus Hambach (Trans. Acad. sci. St. Louis, 1903, 13, p. 54, fig. 15) has a subcylindrical body, with the upper portion of the interambulacral areas strongly elevated above the ambulacrals. The base is flattened or concave. This species was described by Hambach from the Chester limestone of Arkansas, and discovered by K. F. Mather, along with *Pentremites angustus*, in beds of Pennsylvanian age in Arkansas (Bull. Sci. lab. Denison univ., 1915, 18, p. 101, pl. 3, fig. 3-6a).

This species takes its name from the widely diverging margins of the ambulacral areas.

PENTREMITES ALTIMARGINATUS, sp. nov.

Plate 1, fig. 11-13.

This species, which includes the largest forms so far found at Old Baldy, is represented by four specimens, all of whose observable

characteristics agree so closely that there can be no doubt that all belong to the same species.

Description.—Body ovoid, outline rounded, widest just below the middle, and above the base of the ambulacra. Summit flat, base obconical, the opposite sides converging at an angle of about 70° . The radial plates are stout, each fork nearly, if not quite, flat; the suture between adjacent radials slightly depressed. The deltoid plates are large, quadrangular, half as long as the ambulacral areas, and half as wide as long; not quite reaching the summit. The interambulacral areas are furnished with a high, sharply defined rim where they border upon the ambulacra. The ambulacra are about three quarters the length of the body, with sides diverging uniformly to near the summit; median food-groove distinctly depressed. Angular ridges are present on the radials directly below the ambulacra, but they are not prominent. The poral plates are directed upwards.

Dimensions of two specimens in millimeters.

Height.....	20.	20.
Maximum diameter.....	16.	15.
Length of ambulacral area.....	16.	15.
Maximum width of deltoid plates.....	4.5	5.
Length of deltoid plates.....	7.	—
Maximum width of deltoid plates.....	3.5	—
Average number of side-plates in 5 mm.....	15.	15.

Formation and locality.—All the specimens are from the limestone member of the Quadrant formation at Old Baldy, near Virginia City, Montana.

Pentremites altimarginatus differs from *Pentremites conoideus* (Mississippian of Indiana, Illinois, Iowa, Missouri, and Montana) and *Pentremites angustus* (Chester limestone of Arkansas, Trans. Acad. sci. St. Louis, 1903, **13**, p. 53, fig. 14a-b, and Pennsylvanian of Arkansas, Bull. Sci. lab. Denison univ., 1915, **18**, p. 100, pl. 3, fig. 10-13a) in its more rounded form and in the two latter species the base is truncate and the long, narrow ambulacra extend almost the whole length of the body. *Pentremites angustus* has larger deltoid plates and an average of seventeen side-plates in five millimeters.

Pentremites burlingtonensis (Burlington limestone of Iowa) has

"the base much depressed or having the form of a pentagonal dish" (Geol. survey Illinois, 1873, 5, p. 461). The general outline is much too globose, and too wide above the middle. The ambulacra are also too long.

Pentremites chesterensis (Kaskaskia limestone of Illinois) has twelve side-plates in five millimeters. Moreover the deltoid plates project slightly above the apertures on the summit. It also differs from *Pentremites altimarginatus* in having long, comparatively narrow ambulacra, which do not taper downwards appreciably but appear to have subparallel sides.

Pentremites obesus (Millstone grit of Kentucky, Kaskaskia limestone of Illinois, Kentucky, and Missouri) resembles *Pentremites altimarginatus* in shape somewhat, but is a much larger form. Its ambulacra are rather shorter than in the specimens from Old Baldy, and the deltoids also are shorter.

Pentremites godoni (Subcarboniferous; distribution widespread) differs from this form in having a subtruncate base and ambulacra which extend nearly the whole length of the specimen. Moreover *Pentremites godoni* is stelliform in cross-section and *Pentremites altimarginatus* is not.

Pentremites robustus (Millstone grit of Kentucky) has all the sutures in the base depressed. The ambulacra are six sevenths the length of the specimen, and the sides are subparallel. It has eighteen side-plates in five millimeters. Our specimens are rather fragile, but in *Pentremites robustus* "all the main pieces composing the body are of remarkable thickness and strength" (Trans. Acad. sci. St. Louis, 1860, 1, p. 630). Moreover there is no rim bordering the interambulacral areas.

Pentremites maccalliei Schuchert (Bangor limestone of Georgia) has twelve to thirteen side-plates in five millimeters while *Pentremites altimarginatus* has fifteen. The former species is very large and stelliform (Proc. U. S. N. M., 1906, 30, p. 759-760).

The specific name of this form refers to the raised rim between the interambulacral areas and the ambulacra.

PENTREMITES BRADLEYI Meek.

Pentremites bradleyi Meek, Rept. U. S. geol. surv. Montana, Idaho, Wyoming, and Utah, 1873, p. 470. Hambach, Trans. Acad. sci. St. Louis, 1903, 13, p. 56, pl. 5, fig. 7.

This species was originally described by Meek in 1873 in a footnote. His description follows. "A small species like *P. koninckianus*, Hall, but shorter below, and having its pseudambulacra more deeply excavated along the middle, with their pore pieces transverse." It remained for Hambach, in 1903, to supplement this meager and altogether insufficient description by the following words:—"Body small, obtuse, conical. Basal portion almost flat, and resembling that of *Pentremites conoideus* very much, but being more rounded and having a larger articulation surface for the column, in proportion to its size, than *Pentremites conoideus*. Ambulacra broad, excavated along the middle, and having rather narrow integumental plications, there being about twelve to one eighth of an inch. Deltoids visible externally. Genital openings as in all true *Pentremites*.

"This species was first described by Meek, but merely in a footnote, comparing it with *Pentremites koninckianus* = *conoideus* Hall. It differs from *Pentremites conoideus* in being more obtuse, with broader and more deeply excavated ambulacra than *Pentremites conoideus* in which the ambulacra are narrow, more rounded, and the surface plications coarser. The interambulacra are depressed more in *Pentremites conoideus* than in this species. It differs from *Pentremites godoni* in being not as round, with more depressed ambulacra, and in not having the sharp crest-like margin around the sinus.

"Geological formation and locality. Subcarboniferous on the divide between Ross Fork and Lincoln Valley, Montana. First mentioned in F. V. Hayden's Sixth Annual Report of the United States Geological Survey of the Territories, 1873, p. 470. Types in the Smithsonian Collection, numbered 24,529."

PENTREMITES CONOIDEUS Hall.

Pentremites conoideus Hall. Meek, Rept. U. S. geol. surv. Montana, Idaho, Wyoming, and Utah, 1873, p. 470.

This species was listed by Meek in 1873 among fossils collected in Carboniferous strata from the divide between Ross Fork and Lincoln Valley, Montana.

In 1905, Mr. Earl Douglass found a specimen which was identified by Dr. P. E. Raymond as *Pentremites conoideus*, in a decomposed limestone on Old Baldy. From the same stratum a large number of other fossils were obtained, all of them species characteristic of the Madison

limestone. This specimen may be described as follows. The body is rather badly crushed, and lacks the entire apical portion, and one ambulacral area. When perfect the specimen must have been nearly one inch high, conical, with a flat base. The ambulacral areas are long, narrow, and convex, expanding only slightly towards the apex. The lanceet-plate is prominent, narrow, occupying about one half the

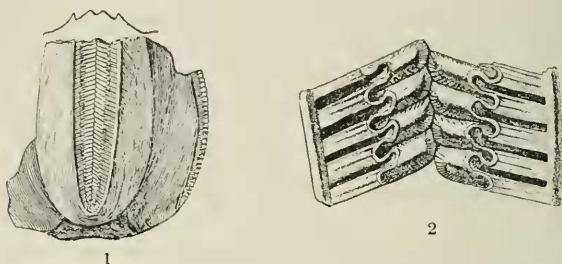


FIG. 1, 2. *Pentremites conoideus* Hall. A crushed specimen from the Madison limestone at Old Baldy, Mont. 1. The specimen. $\times \frac{3}{2}$. 2. Detail of ambulacrum. $\times 10$.

ambulacral area. Side-plates narrow, with minute pits for the insertion of the brachioles. The base is badly fractured, and the sutures of the basal plates are obscured. The fork-plates are large, deeply depressed along the sutures, and ornamented by fine striae which are to some extent parallel to the median suture of the interambulacral area. There are thirteen side-plates in five millimeters. The specimen is in the Carnegie Museum, Pittsburgh, Penn.

PENTREMITES GODONI Defrance.

Pentremites godoni? Defrance. Meek, Rept. U. S. geol. survey, Montana, Idaho, Wyoming, and Utah, 1873, p. 469, 470.

This species, or a closely related form, was noted by Meek in Carboniferous rocks at two localities in Montana, Old Baldy near Virginia City, and the Divide between Ross Fork and Lincoln Valley.

PENTREMITES SUBCONOIDEUS Meek.

Pentremites subconoideus Meek, Rept. U. S. geol. survey, Montana, Idaho, Wyoming, and Utah, 1873, p. 471. Hambach, Trans. Acad. sci. St. Louis, 1903, 13, p. 38.

Meek devoted only a couple of lines to the description of *Pentremites subconoideus*, and placed them in a footnote. The description follows:—"A very small obconic species, much produced below the pseud-ambulacral areas, which are very short, or almost confined to the summit, as in *Codaster*, though it is a true *Pentremite*." Ham-bach, in 1903, considered this form to be the young of *Pentremites pyriformis* ("*Pentremites subconoideus*, Meek, a young form of *Pentremites pyriformis*") though he gave no reason for this statement.

The specimens from which Meek described the species came from the Carboniferous at the Divide between Ross Fork and Lincoln Valley, Montana.

PENTREMITES SYMMETRICUS Hall.

Pentremites symmetricus Hall. Meek, Rept. U. S. geol. survey, Montana, Idaho, Wyoming, and Utah, 1873, p. 469.

After listing the species from the Carboniferous of Old Baldy, Montana, Meek wrote "As far as can be determined from the specimens, it seems to agree well with *Pentremites symmetricus*."

SCHIZOBLASTUS HAYNESI, sp. nov.

Plate 1, fig. 15-20.

Description.—Body small, spheroidal, the greatest diameter exactly in the middle. Basal portion flat, no suggestion of concavity. Summit flat, its diameter rather less than half the maximum thickness of the body. The basal plates are nearly flat (maximum width three millimeters), ornamented by clearly defined ridges running parallel to the sutures. The radials are long, extending nearly the whole length of the body in side-view, ornamented, like the basals, by ridges which run parallel to the base, but diverge somewhat from their mutual suture; the ridges are occasionally interrupted so as to resemble rows of nodules. The diverging ridges on the interambulacral area occupy a leaf-shaped space, between which and the ambulacra are flattened linear areas ornamented by obscure low transverse ridges; this area rises next the ambulacra to a sharp ridge especially at the lower end where it is ornamented by a row of nodules rising from the side next the ambulacra and crossing over to the leaf-shaped

area containing the longitudinal striae. Deltoids small, about as long as wide, somewhat flattened at their apices; they appear to be bounded towards the apical end by an angular suture, which is parallel to the lower suture, but this is in all probability merely an ornamentation. Above this line the deltoids are deflected towards the plane of the summit and somewhat hollowed out so as to simulate grooves. The ambulacra are long and narrow, sides parallel; in side-view occupying the whole height of the body; bordered by the high raised rim of the interambulacral area; the lancet-plate rises in a prominent ridge along the whole length of each ambulacrum. The food-groove is only slightly depressed. There are 28 side-plates in 5 mm. The anal opening is many times larger than any of the spiracles, and is confluent with the two adjacent spiracles.

Dimensions of three specimens in millimeters.

Height.....	6.75	5.5	5.25
Maximum diameter.....	7.	5.5	5.
Length of radial plates.....	6.	4.	?
Maximum width of radial plates.....	3.5	2.75	2.5
Length of deltoid plates.....	1.5	1.5	1.75
Maximum width of deltoid plates....	1.5	1.5	1.5
Average number of side-plates in 5 mm.	28.	28.	28.

Dimensions of the three specimens adjusted to a height of 10 millimeters.

Height.....	10.	10.	10.
Maximum diameter.....	10.4	10.	9.5
Length of radial plates.....	8.9	7.3	?
Maximum width of radial plates.....	5.2	5.	4.8
Length of deltoid plates.....	2.2	2.7	3.3
Maximum width of deltoid plates.....	2.2	2.7	2.86

Formation and locality.—The specimens are from the Madison limestone of Old Baldy and of Squaw Creek, Montana, collected by Dr. W. P. Haynes and the writer.

This species differs from *Schizoblastus lotoblastus* (Subcarboniferous of Arizona and Idaho) in having a base not concave and in being globose, while in *Schizoblastus lotoblastus* the form is subelliptical in outline. Moreover the latter form is distinctly pentalobate at the base.

Schizoblastus granulosus (Keokuk group of Illinois) has a deeply concave base. In *Schizoblastus potteri* (Burlington limestone of Iowa) the forked pieces are short, only one quarter the length of the body. There is also a hook-like projection at the apex of the ambulacral field.

Schizoblastus sampsoni (Chouteau limestone of Missouri) has 18 side-plates in 5 mm. Its height is one fifth greater than its width, and there is a deep groove running the whole length of the ambulacra; in *Schizoblastus haynesi* the food-groove is only slightly depressed. The lateral expansion of the deltoids in *Schizoblastus haynesi* is one quarter the length of the body. On the whole *Schizoblastus haynesi* resembles *Schizoblastus sampsoni* more than any other species, especially in external ornamentation.

SCHIZOBLASTUS LOTOBLASTUS (White).

Granatocrinus lotoblastus White, Prelim. rept. inv. foss., 1874, p. 15; Rept.

U. S. geog. surv. west 100th merid., 1879, 4, p. 80, pl. 5, fig. 3a, b; Bull.

U. S. geol. and geog. surv. terr., 1879, 5, p. 212.

Schizoblastus lotoblastus Weller, Bull. 153, U. S. G. S., 1898, p. 550.

White reported this species originally from Ewell's Spring, Arizona, but later identified it, with some doubt, from the Teton range, near the headwaters of the Teton River, just west of the common boundary of Idaho and Wyoming.

BRACHIOPODA.

CAMAROPHORIA OBESA, sp. nov.

Plate 2, Fig. 13-24.

Description.—Shell small, subglobular in form, subcircular to sub-pentagonal in outline, longer than wide, wider than thick. Both valves are strongly convex; the pedicle-valve is the more strongly arched longitudinally, the brachial valve transversely. In the pedicle-valve the beak is prominent and overhangs the brachial valve considerably. There is a distinct but not strongly marked sinus on the pedicle-valve, within which is a raised median plication. On either side of the sinus are two plications, only the pair bordering the sinus

achieving any prominence; occasionally the only evidence of the outerplication is a sinuosity in the lateral margin. The brachial valve is characterized by a short and not prominent fold divided by a median furrow. On each side there may be one or two short plications. The fold, sinus, and plications on both valves are short, not extending one half the length of the specimen.



FIG. 3. Nine serial sections of the rostral portion of a specimen of *Camarophoria obesa* Clark. Natural size.

Internally, the pedicle-valve shows a pair of dental lamellae near the beak, supported by a median septum. The lamellae are continued anteriorly into a spondylium, well raised from the floor of the valve. The brachial valve has a slightly longer median septum supporting both hinge-plate and cruralium. The hinge-plate is short, and the cruralium extends a short distance beyond the septum.

The surface of the valves is unornamented save for lines of growth placed at irregular intervals.

This species resembles somewhat *C. explanata* (McChesney) which occurs in the Chester group of the Mississippi Basin. That species, however, is wider than long, has more prominent plications, and a broader and, indeed, very wide fold and sinus. *C. obesa* has a much more prominent beak.

Horizon and locality.—Professor J. B. Woodworth and the writer have collected this species from the Madison limestone at Old Baldy, Montana.

AXIODEANEIA, gen. nov.

Description.—Shells subovate to triangularly subovate in outline, the valves subequally convex, the mesial fold and sinus slightly developed or obsolete. Both valves marked by broad, rounded or subangular plications; when the surface is well preserved it is marked by fine radiating striae. In the pedicle-valve the hinge-teeth are small and are supported by slender, vertical, dental lamellae. In the brachial valve a well-defined median septum is present in the rostral portion of the valve, and is divided anteriorly to form a V-

shaped crural cavity; the hinge-plate is divided, the inner margin of each lateral portion being supported by one of the lateral walls of the crural cavity. No cardinal process is present.

It will be seen that *Axiodeaneia* has the external characteristics of *Rhynchotetra* with the internal arrangements of *Paryphorhynchus*.

AXIODEANEIA PLATYPLEURA, sp. nov.

Plate 2, fig. 25-32.

Description.—Shell narrowly subtriangular, nearly twice as long as wide, greatest width one third the length from the anterior end. The sides are flat, two thirds the length of the shell, perpendicular to the plane of the valves, converging toward the beaks, giving the shell a distinctly wedge-shaped appearance. There is no hinge-area. The beak of the pedicle-valve projects beyond the brachial valve slightly. The valves are subequally convex from beak to anterior end; the brachial valve is well rounded from side to side, the pedicle-valve being nearly flat. Both valves are strongly plicated, with the anterior border deeply dentate. There are usually eight plications on the



FIG. 4. Six serial sections of the rostral portion of a specimen of *Ariodeaneia platypleura* Clark. $\times \frac{1}{3}$.

pedicle-valve and nine on the brachial; on both valves the lateral plications become obsolete towards the beaks. The pedicle-valve is marked by a strong median furrow, corresponding to which in the brachial valve is the strong median plication. The plications are subangular at the anterior end; the furrows are wide and rounded. In well-preserved specimens the whole surface is covered with fine radiating striae. Concentric markings are present, but indistinct.

Internally the pedicle-valve possesses two strong dental lamellae which become free from the valve at their lower end slightly in front of the articulated portion of the valves; then rapidly diminish in length and become obsolete at about one third the length of the

shell from the beak. The brachial valve shows a stout median septum which, according to Dr. Haynes's drawings, is formed by the fusion of two mutually convex septa each supporting the hinge-plate. The median septum is divided, forming a large crural cavity, each fork supporting a branch of the hinge-plate. The crural processes seem to be thrown off from both the hinge-plate and the fork of the median septum, so that each process is concave towards the pedicle-valve. None of the dental lamellae, crural processes or median septum extends beyond one third the length of the shell from the beak.

The dimensions of a specimen of average size are as follows:—

Length.....	26 mm.
Width.....	16 mm.
Thickness.....	14.5 mm.
Angle between sides.....	57°
Plications on pedicle valve.....	8
Plications on brachial valve.....	9

The species has been found in quantity in the Madison limestone at Old Baldy Montana, and, by the writer, near Cherry Creek Basin. Entire, free specimens are not common and frequently the shells are crushed. The condition of the beaks is seen only in two very nearly perfect specimens, but in these the pedicle-opening is obscured by damage. Natural casts or moulds of the interior have not been found, and what is known of the interior has been gained by a study of sections drawn by Dr. W. P. Haynes while grinding down the beaks.

This form cannot be mistaken for any other species in the collections from southwestern Montana except perhaps *Camarophoria ringens* (Swallow), identified by Girty from the Yellowstone National Park. I quote from Swallow's description:—"sinus wide and shallow, containing about eight plications.... Surface marked with about fourteen large plications on each valve. Length 1.90; breadth, 1.43; thickness, .99" (Trans. Acad. sci. St. Louis, 1860, 1, p. 653). *Camarophoria ringens* is therefore a much broader form, with a sinus and more plications than *Axiodeanceia platypleura* which has no sinus at all. The small number of plications, the prominent median plication and furrow, the narrow triangular form and the flat sides are sufficient to distinguish this species from any other known form.

GIRTYELLA WOODWORTH, sp. nov.

Plate 2, fig. 1-12.

Description.—Shell small, subpentagonal in outline, longer than wide, greatest width in the middle or somewhat back of the middle. The anterior margin is often concave. Both valves are moderately convex. Longitudinally the pedicle-valve is the more strongly arched, transversely the brachial. The pedicle-valve has a median sinus which begins about six millimeters from the umbo and is low, broad, and rounded. The sinus is not conspicuous in shells less than nine or ten millimeters long. The brachial valve possesses a still more shallow, wide sinus, within which, throughout the length, there is a low, rounded fold. Faint lines of growth occur on each valve.



FIG. 5. Six serial sections of the rostral portion of a specimen of *Girtyella woodworthi* Clark. $\times 2$.

Internally, the dental lamellae of the pedicle-valve are very short, scarcely extending beyond the beak. In the brachial valve, the concave hinge-plate, supported by a median septum is continued for about one third or one quarter the length of the specimen. The socket-plates are deflected upwards from the margins of the valve to meet the hinge-plate, and are continued anteriorly to form the crural processes. The median septum continues to about one third the length of the valve.

This form is more robust and more rounded along the anterior margins than *G. brevilobata* Swallow which occurs in the Chester formation of the Mississippi Valley. The latter has a well-developed mesial sinus in the pedicle-valve, which is much narrower than the sinus in the corresponding valve of *G. woodworthi*. In the brachial valve of *G. brevilobata* the mesial fold in the sinus occurs only at the anterior end, while in *G. woodworthi* it extends all along the sinus.

Horizon and locality.—This species has been collected by Professor J. B. Woodworth and the writer in the Lower Carboniferous (Madison) limestone at Old Baldy, Montana.

Lower and Upper Carboniferous in Montana.

One of the problems in the study of the western Carboniferous is to determine where the line between Upper and Lower Carboniferous should be drawn. If fossils are to be used in reaching a decision it will be necessary to rely mostly upon brachiopods, for not only do they include the great majority of all Carboniferous fossils, at least in southwestern Montana, but the species are for the most part quite easily identified. As a contribution toward the solution of this problem I append lists containing all the brachiopods so far reported from Old Baldy, Montana. They are separated into three groups; the first contains those which occur in the Lower Carboniferous, the second contains those which occur in the Upper Carboniferous, and the third contains those which are known to occur in both Upper and Lower Carboniferous. In compiling these lists I have used the published lists of Meek¹ and Douglass,² and also the collections in the Museum of Comparative Zoölogy made by Professor Woodworth and his students in the Harvard Summer School. My own collections were made while I was a member of the Harvard Summer School in 1915. Weller's Bibliographic index of North American Carboniferous invertebrates³ was the chief source of information regarding geologic ranges. There is much valuable information as to geologic ranges in Girty's Carboniferous formations and faunas of Colorado.⁴

Brachiopods occurring in the Lower Carboniferous.

- Schizophoria resupinata (Martin).
- Leptaena analoga (Phillips).
 - rhomboidalis (Wilkins).
- Schuchertella crenistria (Phillips).
 - inflata (White and Whitfield).
- Orthotetes inaequalis (Hall).
- Chonetes loganensis Hall and Whitfield.
 - ornatus Shumard.
- Productus altonensis Norwood and Pratten.
 - flemingi var. burlingtonensis Hall.
 - laevicostus White.
 - parviformis Girty.

¹ Meek, 1873, Sixth Ann. rept., U. S. geol. surv., of territories for 1872, p. 468-470.

² Douglass, 1905, Annals Carnegie mus., 3, p. 417-420.

³ Weller, 1898, Bull. 153, U. S. G. S.

⁴ Girty, 1903, Prof. paper 16, U. S. G. S.

- Camarophoria ringens (Swallow).
 obesa Clark.
 Camarotoechia metallica (White).
 herrickana Girty.
 Axiodeaneia platypleura Clark.
 Dielasma utah Girty.
 Girtyella woodworthi Clark.
 Spirifer centronatus Winchell.
 centronatus var. semifurcatus Girty.
 grimesi Hall.
 cf. striatus (Martin).
 peculiaris Shumard.
 Reticularia cooperensis (Swallow).
 setigera (Hall).
 Martinia rostrata Girty.
 Spiriferina spinosa (Norwood and Pratten).
 solidirostris Winchell.
 Athyris lamellosa Leveille.
 Eumetria vera (Hall).
 Cleiothyridina crassicardinalis (White).
 crassicardinalis var. nana (Girty).
 Composita claytoni (Hall and Whitfield).
 madisonensis Girty.

Brachiopods occurring in the Upper Carboniferous.

- Derbya crassa (Meek and Hayden).
 Chonetes flemingi Norwood and Pratten.
 Productus costatus Sowerby.
 inflatus McChesney.
 nebrascensis Owen.
 punctatus (Martin).
 Marginifera haydenensis Girty.
 muricata (Norwood and Pratten).
 Pugnax rockymontanus (Marcou).
 Dielasma bovidens (Morton).
 Spirifer rockymontanus Marcou.
 Squammularia perplexa (McChesney).
 Spiriferina kentuckiensis (Shumard).
 octoplicata (Sowerby).
 pulchra (Meek).
 spinosa (Norwood and Pratten).
 Hustedia mormoni (Marcou).
 Cleiothyridina orbicularis (McChesney).
 Composita subtilita (Hall).

Brachiopods occurring in the Upper and Lower Carboniferous.-

Productus cora d'Orbigny.

gallatinensis Girty.

prattenianus Norwood (? = *P. cora*).

scabriculus (Martin).

semireticulatus (Martin).